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ABSTRACT

This paper is intended to serve as the basis for discussion of the scope and place of environmental education in technical and vocational education. It is addressed primarily to administrators, curriculum developers, and other active participants in the definition of scope and content of technical and vocational courses. After a brief introduction that sets out the main reasons why environmental subjects should be given increased attention in technical and vocational education, a second chapter deals with the primary environmental issues involved. Both the outer environment (including such issues as waste disposal and recycling) and the inner environment (the workplace) are considered. Chapter 3 identifies the elements of environmental risks that are related to the various levels and sectors of technical and vocational education. Chapter 4 focuses on the integration of environmental education into the curriculum, including when such elements are best made part of the teaching of other subjects or skills and when they may form a separate subject. Chapter 5 discusses the effects on teacher/instructor training requirements when more attention is given to environmental issues in technical and vocational education. The final chapter summarizes the paper. (YLB)

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Unesco-UNEP International Environmental Education Programme

Environmental Education Series **24**

Environmental Education in Technical and Vocational Education

Sven Grabe

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PREFACE

The target groups of technical and vocational education play an important role through their actions and decisions in changing the indoor and outdoor environment. Environmental changes ought to be sound with respect to health, sanitation, safety, resource utilization and its recycling, waste disposal, pollution of air, water and soil etc. A fundamental step towards this direction is to provide the technical and vocational education trainees and graduates with an awareness, knowledge, skills and commitments on the environment and its relationship to humanity with the purpose of improving the environment and preventing environmental problems. This is a global goal of environmental education.

This document has been prepared in the context of activities of Unesco-UNEP International Environmental Education Programme (IEEP) with the objectives to spur reflections on the need, importance and place of environmental education (EE) in technical and vocational education and to provide general suggestions for the incorporation of EE into TVE. The draft of this document was presented and discussed at the Consultation Meeting on the Incorporation of Environmental Education into Technical and Vocational Education, 10-14 March 1986, Singapore.

Unesco is appreciative of the collaboration of Mr Sven Grabe in the preparation of this document. Suggestions for the improvement of this document in its future revisions will be received with appreciation at IEEP, Division of Science, Technical and Environmental Education, Unesco, 75700 Paris, France.

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FOREWORD

The essential purpose of this paper is to serve as a basis for discussion of the scope and place of environmental education in technical and vocational education. It is addressed primarily to the administrators, curriculum developers and others who participate actively in the definition of scope and content of courses in which skilled workers, technicians and engineers are trained for employment in the various fields of economic activity and, particularly, in industry and agriculture.

The paper is intended to convey both a sense of urgency in reaching these groups in the population with an environmental message and to make them aware of what they can do in their work to arrest the current trends towards irreversible damage to the human environment. It should also convey to them a sense of the key role that they must play in the future in this respect. At the end of their studies they should have a clear view of the environmental issues relating to their respective fields of work, and the skill and knowledge needed to deal with them.

The paper is divided into six main parts. After a brief introduction setting out the main reasons why environmental subjects should be given increased attention in technical and vocational education a second chapter deals in some detail with the main environmental issues which are or may be considered relevant in this context. The third chapter seeks to pin-point the elements of environmental risks which relate to the various levels and sectors of technical and vocational education. Chapter four is primarily concerned with the integration of environmental education into the curricula - when such elements are best made part of the teaching of other subjects or skills, and when they may form a separate subject. Chapter five is mainly devoted to the effects on teacher/instructor training requirements when more attention is given to environmental issues in technical and vocational education. Chapter six, finally, provides a brief summary of the paper, in which the principal aspects and problems are highlighted.

The paper has been written by Sven Grabe, Education/Training Consultant and former senior research officer at the International Labour Office. He was assisted, with special reference to the environmental issues, by Mrs Magdalena Ehrström, PhD, of the Environmental Health Section of the Swedish Board of Social Affairs. Many other persons have been consulted on various aspects of the subject in the course of writing. While the author expresses his sincere thanks for these contributions, he takes full responsibility for his interpretation of the advice given and for any error of fact or judgement that might be found in the paper.

I. INTRODUCTION

Mass media are providing examples every day of the accumulation in recent years of damage to the environment resulting from a wide range of technological applications. Forests are dying and fields losing their fertility due to acid rain, due, originally, to increased use of sulphur-carrying combustibles in the production of energy or heat. Lakes and water streams polluted by detergents, animal and human wastes and fertilizers, pesticides and herbicides leaking from agricultural fields and forest lands, choking fish and other aquatic life through overfertilization, or killing them by direct poisoning. Even more impressive are the occasional - increasingly frequent - reports on gas leaks from chemical plants, explosions and fires caused by sloppy handling of risky operations or neglect in control and maintenance of safety equipment or the smog clouds moving in over large cities, causing death and desease.

There are also almost daily accounts of negative effects on the human environment in industry and in many other fields of economic activity of new materials and equipment, introduced without proper regard to the side-effects which they may have on those who will use them in their work or on the ultimate consumer; asbestos dust causing severe lung damage; faulty isolation of houses providing breeding grounds for moulds emitting poisonous gas; badly organized work places, without proper arrangements for the evacuation of polluted air, dust particles and other impurities or poisonous elements, causing unhealth among workers; insufficient filtration of emissions - by water or air - from housing complexes and factories causing harm to whole areas. These are but a few examples of an accelerating environmental destruction in modern society - destruction of the human environment, destruction of flora and fauna, destruction of human health.

In many cases the explanation given to the accidents that occur, to the destructive side-effects of so many activities in modern society - in the homes, in agriculture, in the factories and even in the offices - is that 'the human factor' is to be blamed. The human factor, in this context, can be translated into two words: ignorance and negligence. Somewhere along the line of actions leading to environmental damage or accidents are the engineers, the technicians or the foremen and workers who did not know, or who did not understand, or who did not care what the effects could be. They may have their place in design, in procurement or in production proper, in maintenance or in management and planning. Somewhere along the line things went wrong and the result may be a slow deterioration in the health of the workers concerned, or the people living in the neighbourhood, or the waterways and the atmosphere. Worse still, perhaps, at any rate more spectacular in a mass media perspective, a sudden explosion, a fire or a gas cloud killing thousands of people and cattle.

Combating ignorance on environmental issues, providing people with the knowledge and skills needed for dealing with them and conveying the sense of responsibility necessary for proper application of these skills and knowledge are the principal objectives of environmental education in technical and vocational education. Giving appropriate attention - to attain these objectives - to environmental education in technical and vocational education is particularly important because of the key roles - as the essential human factors - of the engineers, technicians, foremen and workers in reducing and, if possible, eliminating negative environmental effects of the work that they will be called upon to do.

The Stockholm Conference on the Human Environment, in 1971, attached special importance to the role of education in combating the threats to the human environment. All forms of educational activities should be mobilized to contribute to making young persons and adults aware of both the urgency of the environmental problems of our time and of what can be done, collectively and individually, to turn the trend around. Unesco was given main responsibility for environmental education and for advising governments and the various public and private bodies concerned on how educational programmes and institutions could share in the common effort of a world environmental programme.

Along this general line of policy Unesco has prepared and published a number of studies, undertaken in close co-operation with the United Nations Environment Programme and other international agencies concerned, on how environmental issues might best be covered in the programmes of institutions for general education at the various levels. The purpose of this paper is to carry these efforts one step further by suggesting ways and means for integrating environmental issues also into the programmes and curricula of technical and vocational education.

General issues of environmental education were the subject of the first Intergovernmental Conference on Environmental Education, which was held in Tbilisi (Georgian SSR, USSR, 14-26 October 1977), organized by Unesco in co-operation with the United Nations Environment Programme. The Conference conclusions were supplemented by a survey of international environmental education needs and priorities in which 80 per cent of Unesco's Member States took part. Furthermore an international workshop was held in Belgrade (1975) and regional and subregional meetings on environmental education organized in Africa, the Arab States, Asia, Europe and Latin America.

The Tbilisi Conference adopted 41 recommendations covering a wide range of questions relating to national as well as international aspects of environmental education. Of special relevance to the present study are the recommendations relating to the aims and objectives of environmental education, guiding principles to be applied in the design of programmes and the selection of target populations, and to educational methodology.

Emphasizing the importance of developing 'understanding [of] the complex relations between socio-economic development and the improvement of the environment' Recommendation No. 1 sets out as a basic aim of environmental education 'to succeed in making individuals and communities understand the complex nature of the natural and the built environments resulting from the interaction of their biological, physical, social, economic and cultural aspects, and acquire the knowledge, values, attitudes and practical skills to participate in a responsible and effective way in anticipating and solving environmental problems, and in the management of the quality of the environment'. As regards educational content, environmental education should 'provide the necessary knowledge for interpretation of the complex phenomena which shape the environment and encourage those ethical, economic and aesthetic values which, constituting the basis of self-discipline, will further the development of conduct compatible with the preservation and improvement of the environment; it should also provide a wide range of practical skills required in the devising and application of effective solutions to environmental problems'.

With regard to target populations the same recommendation states that 'environmental education should cater to all ages and socio-professional groups in the population'; it mentions, in this context, besides the general non-specialist public of young people and adults, particular social groups whose professional activities affect the quality of the environment and scientists and technicians whose specialized research and work will lay the foundations of knowledge on which education, training and efficient management of the environment should be based.

Recommendation No. 2 distinguishes between five categories of environmental education objectives: awareness, knowledge, attitudes, skills and participation. It emphasises that environmental education should consider the environment in its totality, be a continuous lifelong process, be interdisciplinary in its approach, examine major environmental issues from local, regional, national and international points of view, focus on current and potential environmental situations, stress the value and necessity for local, national and international co-operation in approaching environmental issues, relate the studies to plans for development and growth and help learners discover the symptoms and real causes of environmental problems.

With reference to educational methodology several recommendations emphasize the need for a flexible approach and for the integration of environmental issues into the teaching of, for instance, the natural and social sciences and technology. The interdisciplinary nature of environmental problems - and their solutions - is a recurrent theme in many of the recommendations, as is the need for a problem-solving and action-oriented approach in teaching. Special reference is made to the effects on the environment of the work of many professionals (reference being made to engineers, architects, administrators, planners (Recommendation No. 11) and teachers (Recommendation No. 17)) stressing the need for including environmental issues in their pre-service training - including postgraduate studies - as well as special in-service courses.

The principal subject of the recommendations of the Tbilisi Conference is the broad environmental issues. There is little mention of the specific problems that should be dealt with at the various levels of general education or in technical and vocational education. These have been the subject of further studies carried out by Unesco in close co-operation with the United Nations Environment Programme and by various Specialized Agencies such as the International Labour Office, FAO, WHO and others, including a wide range of non-governmental organizations and regional bodies. The range of such activities is too wide for special mention to be made here. Only a few examples directly relevant to the present paper may be given.

Unesco has, in the course of the eight years which have passed since the Tbilisi Conference adopted its recommendations, published practical guidelines and discussion guides relating to strategies for developing an environmental education curriculum and the training of teachers in environmental education (both in 1980). It has further published modules for pre-service training of teachers and supervisors for primary schools and science teachers and supervisors for secondary schools as well as a module for in-service training of science teachers and supervisors for secondary schools.

Along the same lines of approach but with a different target population the ILO Management Development Branch is currently developing basic training materials for managers, companies and training institutions covering such

aspects as general environmental management, project management and the environment and production management and the environment. Also this work is carried out in close co-operation with the United Nations Environmental Programme and with its suppport. Several management institutions have participated in implementing the project.

Engineers and agronomists, like many other professional people, industrial and agricultural technicians, and specialized and skilled workers - the principal graduates of the systems of technical and vocational education - need special environmental education for two different reasons:

(1) they participate in the development and production processes which influence the human environment; and

(2) they are, themselves, directly affected by that environment.

It is to both these roles of technical professional and executive personnel in the various fields of economic activity that environmental education must be directed when forming part of a technical and vocational education process. It is with these two roles in mind that the syllabuses and programmes of environmental education must be designed for both young people who are receiving their initial technical or vocational education and those adults who are already employed in technical work.

Like all technical and vocational education environmental aspects of technical activities must be subjects of lifelong education. Technological applications in agriculture, in industry, in medical services and in many other fields of economic and social activity are undergoing rapid change. New materials are being developed with other properties - other risks to the inner and outer environments - than those previously used. New processes are being introduced, new organizational patterns tried, which may have a different impact on those directly involved in the work or on the environment close by or even far away.

Environmental education tasks are further complicated by the very wide range of human activities involved. The graduates of technical and vocational education are employed in practically every type of work, at every level of human hierarchies. Environmental problems relating to the mining industry differ in most respects from those relating for instance to agriculture or, again, from those relating to the mechanical industry, the transport industry or clerical and office occupations.

A few of them are general - relating to the relationship of man to his environment in general - are common to all fields of economic and social activity. It is assumed here that these, on the whole, will be covered as environmental aspects in general education and that what needs to be done with respect to these general environmental issues in technical and vocational education is to reinforce what has already been taught at an earlier stage in the total educational process. The main issues to be dealt with below are those which are technologically specific to the various branches of activity or to groups among them. This in itself is a sufficiently wide-ranging issue, given the wide variety of tasks undertaken in modern society by the various categories of technical personnel.

The wide variety of tasks is only one of the complications in a discussion of environmental education in technical and vocational education. A second is the wide variety of forms in which such education is provided and the often broad range of public and private authorities and other bodies involved in its administration. Higher, intermediate and lower technical education are often the responsibility of three distinct authorities. Higher technical education may be provided by university level institutions - if not by the universities themselves; intermediate - technician level - technical education may be an integral part of the system of secondary education or constitute a separate system of post-secondary specialized education or more generally a system of further education subsequent to the period of compulsory education. It is sometimes integrated into, sometimes separate from, sometimes built on top of the vocational education system. The vocational education system, finally, may function entirely within the system of secondary education or form a separate system of further education, be full time or part time - like in some countries at least a part of the system of intermediate technical education.

Adult technical and vocational education presents an even more complex picture. While there has been a rapid development in extra-mural activities and adult education programmes in most systems of technical and vocational education, a substantial part of such educational activities are carried out, in most countries, by a wide variety of public and private bodies. These include, in addition to the adult training systems administered by public authorities, research institutions, specialized consultants and training institutes concerned with particular technological applications or with individual functions, for instance in management and supervision, extension services with special responsibility for, for instance agriculture or animal husbandry - often supplemented by rural education programmes initiated by farmers' co-operatives - or for small industry development, by equipment manufacturers and other input producers and, last but not least, by operating enterprises. To this should be added that only a proportion - varying according to the level reached in the development of national public or private technical and vocational education systems - of the technical personnel engaged in agriculture - including independent farmers - the various fields of industry and of those doing technical work in other fields of economic and social activity, have received any formal technical or vocational education at all. Large sectors of the economy, particularly in developing countries, are not served by any formalized system of technical and vocational education at all, whether full time or part time. They depend for their supply of technically skilled personnel almost entirely on informal training processes in which knowledge and skills are just picked up on-the-job.

It is with these various complications in mind that the discussion of environmental education in technical and vocational education should be interpreted and read.

II. ENVIRONMENTAL ISSUES AND RISKS

Technical personnel are exposed to the same general environmental risks and may affect the environment in the same ways as any other people. In other words, they need the same general environmental education - adapted to the particular circumstances and environmental characteristics of the locality, the region and the country in which they are living. As individuals they may contribute in the same way as other people to polluting the air, the water-streams and the lakes, spread non-destructible wastes in the fields and forests, cause destruction through careless handling of fire, neglect the proper maintenance of private vehicles, furnaces and other fuel-burning equipment resulting in unduly 'dirty' emissions of gases, heavy metals and sulphurous substances. Like all others they may actively help cleaning up the environment by proper disposal of wastes, adequate maintenance of equipment, choosing methods of heating and waste disposal that minimizes environmental risks. Like all others they may participate in community action to keep rivers and other waterways clean, to collect undestructable wastes in nature and exercise civic control of the ways in which their community is handling environmental issues. Like all others they can actively contribute to environmental maintenance and improvement by properly sorting the wastes produced in their households, by participating in group actions to plant trees to arrest soil erosion due to deforestation and take other kinds of constructive action to improve the environment.

All this belongs to the general environmental issues which should be dealt with already in the course of their general education before entry into technical and vocational education; the awareness, knowledge, attitudes, skills and will to participate in group action should be reinforced during their technical or vocational education building on what has gone before. In this respect environmental education in technical and vocational education should be seen as a continuation of general education, designed to provide further environmental education.

Technical personnel - receiving their training in courses of technical and vocational education for young persons as well as for adults - do, however, require more than the general introduction into environmental issues than those who attend general education only. They need to learn to appreciate - identify and evaluate - the effects of their professional work on the environment; the risks to nature at large involved in the types of operations that they will be or are performing in their occupations. They need, in particular, to be aware of the environmental properties of the raw materials they are using, the processes which they are designing or controlling and the risks that those who perform them and those around - at the work place or around it - may be exposed to. Those around, in this context includes not only the human beings but the flora and fauna, the soil, the air and the water in the immediate neighbourhood as well as further away.

For the sake of clarity a distinction will be made below between the 'outer' and the 'inner' environment. The outer environment is then understood as the 'world around' - the inner as the work place - the farm, the factory, the office in which technical personnel is employed. The two often overlap. An explosion in a factory may have effects far beyond the walls to the outside world. The overheating in the Three Mile Island nuclear energy plant

threatened not only those directly involved in the operation of the process but also those living miles away. The Bhopal cloud of poisonous gas was carried by the wind through a heavily populated area killing or severely injuring thousands of people, cattle and other living beings. What started as an accident related to the inner environment involving great risks to those directly involved in the process, rapidly developed into a catastrophe in the area down-wind from the plant.

The inner environment is not necessarily a closed area like a factory. It includes the fields and pastures of farms as well as the buildings in which animals are housed. It includes the roads, railways and waterways which serve for the transportation of goods. The main distinction is between environmental risks suffered by the people at work and those which relate to the outside world.

It should be recalled here that technical staff in agriculture, in industry, in medical and social services, or engaged in other economic or social activities are charged with a great variety of functions. Graduates from the same class of higher technical education may, ten years later be engaged in a wide variety of jobs, differently related to environmental issues. Some may be working in design and development of products, equipment or processes, or in the procurement and quality control of materials and equipment; others in production proper, still others in marketing, sales or service to customers. The same - mutatis mutandis - applies to both technicians and skilled and specialized workers. Trained electricians or mechanics are engaged in both production and maintenance, in factory as well as field work, and in a wide range of economic and social activities. Mechanization and computerization of many functions in the various branches of industry, in medical services, in agriculture and forestry, and in clerical and commercial occupations has profoundly modified the structure of employment in all these fields of economic and social activity and, in particular, widened the field of employment for technically trained personnel.

The wide range of functions carried out by technical staff serves to emphasize the need for lifelong environmental education. So does the fact that technical staff over the years often change their fields of work and the level of their responsibilities. The skilled worker, trained as a mechanic or as an electrician may, 10 or 15 years after graduation from a vocational school, serve as foreman in a maintenance team or a production unit. A technician may go through a number of specialized jobs with little - or as the case may be major, for instance as a safety engineer - responsibility for environmental issues, ending up as a unit manager, responsible for both the production and the safety and health of the workers. Graduate engineers often rise to senior management positions.

There can be no question of grading the various environmental issues that need to be taken into account in environmental education in technical and vocational education according to their level of urgency or the severity of their effects on human life and society as a whole. They are all urgent - in many cases irreversible damage has already occurred, for instance through deforestation leading to erosion and flooding. They differ between them in the sense that some are more relevant to one type of occupational specialization - for instance the environmental properties such as the breaking down of chemical substances in nature being of particular importance in the training of chemical technicians and engineers - than to those in other lines of technical and vocational education. Moreover, what may be a priority aspect in

environmental education for one or a few lines of technical and vocational education or at one or the other level of such education, may be of lesser importance in another line or at another level. The determining factor should be the impact that the work of the individual may have on the environment, the type of operations he is likely to supervise or handle.

Technical staff are trained to become executives in production and maintenance. A principal aim in their technical and vocational education should be to create an awareness of the relationships between their particular field of activity and the environment and an understanding for the environmental risks involved in it; to provide the knowledge they need to choose environmentally safe ways of carrying out their functions; to develop the skills required for applying that knowledge in their work; and to help them develop the attitudes and the motivation for actively participating in environmental improvement and protection.

1. The outer environment

The issues relating to the outer environment of special importance to technical staff concern the impact on the quality of life on earth of the type of activity in which they are engaged. Central aspects are the impact of emissions from productive units carried through air or water with humans, animals and plants at the receiving end. Included under this general characterization are also the transformations taking place for instance in polluted air - the 'acid rain problem', for instance - and the chains of accumulation in nature - for instance the absorption of heavy metals such as mercury by micro-organisms, finally ending up in the larger species of fish, or the effects of DDT and other similar substances, such as road salt on bird life and the fertility of birds - the 'silent spring syndrome'.

Central environmental issues are also the properties of products - of increasing importance with the proliferation of chemical substances used in a widening range of economic activities including agriculture and manufacturing industry - the safety and health risks that may be connected with their use and the impact they may have on the environment when used. Examples of problems in this respect are the health risks accompanying the handling of asbestos, the gas emissions that may result from improper insulation and ventilation favouring the growth of moulds, but also the construction of toys that may endanger the health or even the life of children playing with them. A third central theme should be the effects of exploitation of natural resources - whether limited or - including, for instance such aspects as the effects of selective felling of trees in natural forests resulting in secondary bush growth and disappearance of the valuable species, clear cutting of forest land resulting in erosion and precipitate evacuation of rain water. Examples from other industries include for instance the undermining of land or sea bottoms by the extraction of gas - the sinking Venice - or salt mining causing risks for the mines to cave in.

Waste disposal

The perhaps most generalized issue of environmental protection relates to the emissions into the air or into waterways and lakes of polluted gas or fluids and the dumping of non-recuperable wastes from manufacturing processes. Problems relating to this aspect of environmental pollution have often been highlighted in recent years in the mass media. They are of particular relevance to technical staff because the engineers, technicians and skilled and

specialized workers in agriculture and industry often have a key role to play in reducing or eliminating such malpractices. Moreover, until recently industrial and other undertakings mostly tended to handle such matters rather carelessly believing that nature would take care of it. Ships were recklessly cleaning their oil tanks in open sea; waste oil from machines and engines emptied into rivers and lakes or simply thrown out where it happened to be convenient, poisonous materials burried a few metres below ground, processes involving radioactive or poisonous raw materials or by-products started without planning for the proper disposal or safe storage of the wastes. The landscape in mining areas is often marked by the mountains of non-coal wastes brought up from underground to pave the way to the coal-carrying levels, metal producing regions by the huge slag-heaps which have accumulated over the years. In regions, where the ore contains high percentages of poisonous substances, such as arsenic, a secondary effect has often been pollution of the water supply underground making whole areas uninhabitable.

Most common - and therefore an important element in environmental education in most lines of technical and vocational education - is pollution of air and water through direct emissions or through drainage channels. This includes the pollution of the air through insufficient filtering of exhaust gases from coal and oil-burning furnaces or smelting operations in metal-producing plants, foundries and other similar installations. Technically the problem includes the emission into the air of sulphuric elements, dust particles and soot, and other by-products of combustion processes. The polluting agents differ largely between processes but the effects are similarly destructive on the environment.

Waste disposal problems are found in practically all types of human activity. It would carry too far in this context to try and provide a comprehensive listing of them. They include emissions of fibre from textile factories - with grave pollution problems in waterways and lakes, spillwater from chemical and pharmaceutical factories, from pulp-mills and paper-mills, causing death to fish and other aquatic organisms, drainage of organic materials from slaughterhouses and spillouts from farms - particularly the specialized ones with large numbers of animals, the mixture of organic and non-organic substances from leather tanning operations - briefly all types of human activities from which residuals may find their ways into the waterways and lakes, seep down into the groundwater or let out into the air.

The process is complicated by the fact that many substances, which may be inoffensive in small quantities are often enriched in nature or may change their properties through structural transformation, when mixed with other elements. Exposure during short periods of time to toxic substances may be inoffensive - over time the substance is concentrated in the liver or the kidneys of humans or animals, with disease-provoking or fatal effects. 'Mad as a hatter' is an expression which has its roots in long-time exposure to mercury-poisoning from the chemicals used in the manufacturing of hats. The decline in numbers of many species of wild birds in recent years is due to the effects of chemicals indiscriminately spread in the forests, absorbed by smaller animals such as mice and voles, the concentration of poisonous substances within their bodies and then eaten by the eagles and other birds of prey.

Transformation of wastes is perhaps best illustrated by the concentration of sulphuroxides in the clouds, and the chemical process, which transforms them into sulphuric acid, picking up hydrogen from the air and the water. The process is further complicated by the fact that the process takes place at a

high elevation and that the clouds are transported by the winds to other areas - the acid rain phenomenon already mentioned above. Similar transportation processes take place in waterways and lakes. One factory may spill out quantities, which are well below the permitted minimum. But when a larger number of factories have their outlets into the same waters - as for instance the many paper- and pulp-mills around the Baltic Sea in Scandinavia - the effects are often disastrous. Here the environmental problem is further complicated by the large number of countries surrounding the Sea making its solution depend on agreements between a wide range of authorities. Similarly internationalized environmental problems exist with regard to rivers - the Rhine is one example - flowing through several countries and with environmental destruction due to wind-transported substances. That it can be a question of large distances is illustrated by the 'red snow' phenomenon for instance in Switzerland; the dust particles which colour the snow have their origin in northern Africa and the Saharan desert more than a thousand miles to the south. Well known are also the ashes from volcanic eruptions, which have been transported by high-level winds to areas on the other side of the globe.

Equally destructive in recent years has been the over-fertilization of waterways and lakes. Again an indirect process. Natural and artificial fertilizers find their ways into the waters - by direct outlets or through drainage - seaweeds thrive and consume greater quantities of oxygen in their growth resulting in the gradual death of fish and other aquatic animal life depending on an adequate supply of oxygen.

Another type of environmental problem is illustrated by the slag-heaps and other mountains of non-recuperable materials found particularly in mining areas and in metal-producing districts. Open-pit mines are left without restoring the landscape when the economically valuable ores have been exhausted. Limestone quarries appear as open wounds in mountainous regions. Brick-making plants are surrounded with heaps of broken bricks, cement-ware factories by bits and pieces of tubes and other pieces which did not come out right from the manufacturing process. Such environmental damage also takes place on a smaller scale for instance in construction work - waste materials, including plastics and what-not are simply ploughed under, when landscaping is done on completion of the building phase.

Much such destruction is unnecessary. Waste disposal in factories and farms can be kept under control; slag, residuals from tile and brick manufacturing and building/construction activities can be used for land-fills; open-pit mining areas restored by proper landscaping; the responsibility for seeing to it that this is done properly falls, to a large extent, on the technical personnel involved in the process. One of the major aims of environmental education in technical and vocational education should be to make students in initial and further education realize their responsibility in these fields and to direct their attention to the techniques which apply to their particular fields of activity and their level of responsibility.

Recuperation and recycling

Much attention has been given in recent years to possibilities for recycling of raw materials that can be extracted from wastes from households and industrial operations. Great progress has been made in many countries - particularly the industrial ones - in recycling used paper, in resmelting of shavings and chips from metal-working industries, in collecting and reusing bottles and other glass materials and aluminium from cans and other packaging.

X-ray films have proved an important source for recycling of silver, and used car and other batteries for the recycling of lead, mercury and other precious metals.

Most of these activities for recuperation of materials which would otherwise go to waste have their origin in environmental considerations. Waste materials spread in nature can be reduced through levying an environmental fee on bottles and cans - repayment encourages the collection. But there are also economic considerations involved. Recycling of paper is often a less expensive process than using new fibre. The energy required for resmelting aluminium is considerably less than what is needed for producing aluminium out of bauxite. Recuperation of silver from films has proved a highly profitable business particularly in periods of high raw material prices. Moreover, particularly as regards heavier items such as glass, economies can be made in reducing the quantities of waste that must be transported and incinerated.

The distinction between recuperable and reusable, on the one hand, and non-recuperable, non-reusable, on the other, has been sharpened with technological progress and as environmental considerations have been applied increasingly to human and industrial wastes. More and more materials are today recuperated and reused, separation processes have been further developed as communities and industries have become aware of both the damage that indiscriminate waste disposal can cause to the environment and of the savings that can be made by more discriminate handling of wastes and by-products.

Filtering and other separation techniques, relating to gaseous emissions as well as water-borne materials and substances dissolved in water should constitute central elements in environmental education in technical and vocational education.

For technical personnel the content should cover all the three basic aspects of environmental protection and improvement; the what, the why and the how. It should cover, with reference to the particular field in which the individual student is likely to be engaged or is already working:

(1) the elements within his particular field of economic activity that may have an impact on the outer environment, put people, flora and fauna at risk if the process gets out of control or, more commonly, if wastes are dispersed indiscriminately;

(2) know what can and should be done to eliminate the risk factors or to keep them under control within permissible limits - and how this is done;

(3) know how to estimate the risks and to calculate costs and benefits - including long-term environmental cost - of eliminating them.

2. The inner environment

Environmental education relating to the inner environment - the work place - differs in many respects from that relating to more global environmental aspects. Common features are knowledge of poisonous elements used in the work processes, accident risks relating for instance to the storage of gases and inflammable materials, which, if the maintenance work is not properly done, or unsafe methods used, may be equally threatening to those at the work place as to the world around. But the main concern of environmental

education relating to the inner environment at the work place is the safety and health of those employed. Main aspects are, for instance, such environmental factors as ventilation and more generally clean air, the climatic conditions (heat and cold), noise and vibration, the organization of the work place - including for instance traffic rules - the risks involved in the handling of the various types of equipment and materials - including health risks - the proper use and storage of dangerous substances, and potential exposure to radiation.

Despite the important progress made in the past few decades in both identifying risk factors in different types of work and preventing accidents and ill health due to work place conditions, many work places still provide a dangerous environment for those who are employed. Many managers and engineers are unaware of the risks involved in the different types of work done under their supervision or do not care sufficiently or do not know how to remove the risks. Many technicians and skilled workers are not sufficiently informed - or again do not care sufficiently - for taking the precautions required to avoid accidents to happen or occupational diseases to develop. Teachers and instructors in technical and vocational education do not always pay sufficient attention to either the broader aspects of the internal environment or to the precautions that the individual must take to protect himself against accidents and ill health in his work. New workers and other technical staff are introduced to the work in farms and factories without a proper introduction to the environmental risks involved - safety training might be limited to occasional campaigns or to putting up a few posters in the shop, drawing attention to particularly frequently occurring risks such as oil-spills on the floor or careless materials handling in the transportation of parts in production.

The risks found in the inner environment can be ranged under five main headings:

(1) Organizational risks. These relate in the first instance to the organization of the work process and the order kept at the place of work. They concern in particular the transportation of raw materials, semi-finished and finished products through the workshop (transport lanes marked and kept open), including overhead transportation (falling objects, safe strapping, etc.), trucking and other means of ground transport. They also concern the procedures for the initial safety instruction of new employees, the distribution of responsibility for maintenance and repair of equipment and the storage of inflammable or otherwise dangerous materials used in the work process, the supervision of the application of safety rules and other similar organizational aspects and instructional requirements, including emergency action in cases of accidents, fire or gas leaks.

(2) Equipment-related risks. These are primarily concerned with the safety and health of the individual. Action required includes the measures to be taken or maintained to avoid being cut, squeezed or otherwise wounded by the tools and other equipment used in the work process, precautions to be taken in working with vibrating tools, the muffling of excessive noise, and risks for impairment due to climatological factors such as extreme cold or heat. Of potentially increasing importance - unless technological change will solve the problem - is protection against radiation from the various types of screen used in a widening range of operations in both offices and

factories. Related to the equipment used are also such traditional health aspects as maintaining the right posture at the work place, or using the best techniques in lifting heavy loads - potentially less applicable today in view of increasing mechanization of all such operations, but still the cause of ill health and accidents at many work places.

(3) Process-related risks. These include the safe handling of raw materials, and intermediate and final products. Involved are risks in handling cancerogeneous materials, substances which may cause skin disease or damage to the eyes or, when inhaled to the lungs or other inner organs of the body. Safety training and instruction may also relate to for instance risks connected with the use of welding equipment (gas emissions, eye damage, protection of self and others against welding sparks - including fire risks involved in such work), self-ignition and other fire risks, risks relating to evaporation of for instance solvents and inflammables, proper use of explosive materials, including storage of gas tubes. The examples could be multiplied but the above may suffice to exemplify the types of risks that need to be covered in process-related environmental education.

(4) Product-related risks. These include the precautions that should be taken by the users of the product and relate in the first instance to communications from the producer to the client. They involve the proper formulation of instructions for use and extramural services rendered by the producer as part of sales or after-sales service. They also involve the contacts between producer and institutions of technical and vocational education, for instance the contacts between the producers of artificial fertilizers, pesticides, weed-killers and other chemical substances, on the one hand and agricultural and horticultural educational institutions on the other.

Many of the risks referred to above are straightforward cause and effect connections between an environmental factor and a particular type of accident or illness. Some are well established - methods to handle them have been worked out and embodied in legislation or in recommendations by the national authorities; a wide range of safety hazards and health risks are covered in international conventions and recommendations - particularly those adopted by the International Labour Conference or by expert meetings arranged by the International Labour Office. Data on safety hazards and occupational health risks are continuously recorded by the International Occupational Safety and Health Information Centre (CIS) of the International Labour Office in Geneva which publishes such data and runs a computer-assisted data bank service open to national authorities and other interested parties. The data also include information on measures to be taken to reduce or eliminate such risk factors in the working environment.

Technological development and, in particular, the intensive work done in the chemical industry and related fields of technology to develop new substances or to make use of known chemical compounds in new products make it necessary to make environmental education for technical personnel a lifelong activity. Knowledge acquired some years ago is rapidly outdated as new technologies are introduced, new tools acquired, new substances added to the traditional ones or replacing them. A well known example is the mechanization and extended use of fertilizers, pesticides and weed-killers in agriculture, a

change in practices and technology, which has led to a number of new problems for those employed in the industry. Traffic accidents (tractors tipping over for instance), excess fertilization of fields, skin damage from handling of toxic substances have multiplied and necessitated a response in the form of more intensive education for farmers and farm workers on the proper handling of the new technology and the new means for increased productivity. The trend towards specialization in agriculture - often with potentially negative effects on the environment - has added further material that must be covered in the initial and further environmental education of farmers and their workers. This concerns both the inner and the outer environment as incompetent handling of the new agricultural technology may have damaging effects both as regards the individuals directly concerned in the work process and vis-à-vis the outer environment.

III. TECHNICAL AND VOCATIONAL EDUCATION SYSTEMS

To design programmes of environmental education for technical and vocational education systems is a complex task. The main reason for this is the complexity of such systems - the wide range of technological applications covered by them and the many levels at which such education is provided. When the design is to cover also adult further education on environmental issues a further complication is the wide spread between functions carried by technical personnel at the various levels. To this should be added the many public and private bodies - educational authorities, labour inspectorates, technical research and development institutions and operating enterprises - which all have contributions to make in the selection of priorities in environmental education for technical personnel and in the provision of such education in schools and technical colleges and institutes of technology, in full-time and part-time education or in specialized programmes of adult education.

Internationally the situation is even more complicated by the fact that different countries approach the organization and implementation of programmes of technical and vocational education differently.

Higher technical education - the training of graduate engineers - for the more responsible levels of work in the various fields of technical activity has by now been institutionalized in most countries and generally forms part - although in many cases a separate entity - of the university system of higher education. Qualifications for entry are mostly through graduation from science streams in the secondary school - previous practices particularly in Anglo-Saxon countries of requiring an apprenticeship (ordinary or 'graduate') are, on the whole abandoned. Studies are primarily theoretical with a complement of laboratory type activities and some countries work in training workshops attached to the institution. The extent to which direct practice in production is included in the curriculum varies greatly between countries - the general trend is towards a reduction through transfer of practical activities to laboratories and institution-run workshops and replacing various kinds of part-time or sandwich educational arrangements and programmes by full-time studies.

The same trends are found at the intermediate levels of technical education, although practices at this level differ more widely between countries. It is also less homogeneous; some countries distinguish between 'higher' and 'lower' level technicians with different arrangements for their initial technical education. While secondary technical schools and colleges for further education have, on the whole, and in a wide range of countries, taken over technical education at this level, the trend in several countries is either to move intermediate technical education to post-secondary educational institutions or to create a higher level of intermediate technical education, either as a prolongation of the technical streams in secondary education or by inserting a new form of technical education between that of secondary technical education and higher technical education at university level.

Programmes of intermediate technical education as a rule give more room for practical technical work experience than those at the higher level. Some systems require completed apprenticeship or vocational education for entry into intermediate technical education. In some countries the approach differs

between lines of technical education as to the amount of practical work experience in industry or elsewhere required of the students. In developing countries more emphasis is usually placed on training in institution-annexed workshops - often for the simple reason that industry does not have the capacity to accommodate large numbers of technician trainees for practical experience on-the-job. Cost considerations and also concern that production conditions should as far as possible be similated in the educational process have led to a search in such institutions for productive work to be done in the training institutions.

Trends in lower technical and vocational education - in which specialized and skilled workers receive their initial training - are even more diverse and in some respects more complex. Traditional forms of skilled worker training through apprenticeship are still prevalent in some countries and at some levels of economic activity. It is the essential training system in such industrial countries as Austria, the Federal Republic of Germany and Switzerland; it constitutes an important complement to the vocational education system in France. It involves a sharing of responsibility for the educational process between schools of further education, providing part-time - on day release or block release basis - general and technical education, and industrial or artisanal enterprises, but also banks, insurance companies and other undertakings with primarily clerical or administrative functions, which provide the essential practical instruction and work experience - a 'dual' system of vocational education. Responsibility is also shared as regards examinations, although public authorities are also involved in the evaluation and quality control.

Apprenticeship has for a long period of time been on the decline in both industrial and developing countries. The apprenticeship approach to vocational education has, however, attracted new interest in recent years for a number of reasons. One has been that the employment records of those who received their initial training in a dual system have proved more favourable than the employment experience of those trained in full-time courses within the educational system. Moreover, accelerating technical change and the high cost of training off-the-job have forced the vocational school to seek closer collaboration with industry in training new generations of specialized and skilled workers.

Trends in the apprenticeship systems are generally towards devoting more time to classroom instruction than in the past. In a number of countries initiation into a particular field of work has also been transferred from the enterprises to schools, leaving less time to on-the-job instruction and work experience; at the same time training periods are being reduced, particularly in countries where the initial training lasted for four to five years - an accommodation also to the general trend towards a higher age of intake necessitated by prolongation of compulsory schooling.

Apprenticeship also still plays a major role in the training of skilled workers in the informal parts of the economies of developing countries. Such apprenticeship is, however, seldom officially recognized; it is run on an entirely informal, traditional basis and is not supplemented by further general and technical education along the lines of an established dual system. This continues to be the case despite the fact that a wide range of developing countries have adopted vocational training and apprenticeship legislation in recent years with the aim of raising the quality level and expanding training through apprenticeship, a legislation, which, as might be regretted, has primarily aimed at stimulating training through apprenticeship in larger scale enterprises in the modern sector.

The trend towards a revival of traditional - but improved - apprenticeship practices and systems is paralleled by more 'outgoing' attitudes in the systems of vocational education, which form part of the system of secondary education or have been established as separate systems outside the field of responsibility of the educational authorities. It is increasingly realized that schools and training centres can only partly simulate the types of work done in industry or other fields of economic activity, that direct work experience in a productive setting needs to be added to the skills developed off-the-job. A wide range of countries - such as the socialist countries of Eastern Europe - have arranged for special relationships to be established between factories and collective farms on the one hand and the technical and vocational schools, from which they are likely to recruit new generations of skilled workers, on the other. Students in vocational education spend varying periods on-the-job in the factory or collective farm, which also supply part-time instructors to the schools. Similarly, students in technical education carry out their examination research and studies within the factory or farm. Closer ties with the local and regional economies and enterprises is a common trend also in many other countries, both industrial and developing.

These trends both facilitate and complicate the task of introducing or extending environmental education in technical and vocational education. Increasing institutionalization of the educational process makes it easier to develop environmental elements in the various subjects taught in related general and technical education. Standardization of programmes and examinations makes it possible to provide for environmental elements to be taken properly into account in the teaching process. But the wider distribution of responsibility for, in particular practical training, necessitates contact between those concerned with the development of environmental education and a wider range of persons directly involved in parts of the educational process. While in countries where technical and vocational education has been highly institutionalized there usually was one single authority - a technical education department of the Ministry of Education, for instance - responsible for programming the whole system, and the teachers in vocational education constituted the only - or at least major - channel through which innovations in programmes could be obtained, increased use of enterprises for practical training now necessitates alerting also the instructor and supervisory staff in the enterprises to ensure full impact.

A complicating factor in the design of environmental education in technical and vocational education is the degree of specialization and the great differences in subject-matter taught in the various streams of technical and vocational education. Higher technical education is normally relatively broadly conceived - its graduates prepare for employment in broadly defined occupational areas, such as mechanical or electrical engineering, chemical engineering or architecture. The contents of environmental education programmes they require could be designed along more or less the same lines for most specializations - with special emphasis on the directly subject-related environmental problems in individual technical subjects.

Specialization gets more pronounced and needs to be taken more into account at intermediate and lower technical and vocational education. While the practices differ between countries, technicians are divided between a wider range of streams than students in higher technical education; at the level of lower technical and vocational education the number of specializations is often extremely high. In several industrial countries the number of 'apprenticeable occupations' is somewhere between 350 and 700 and some systems

of vocational educacion cater for as many as 100 different skilled occupations, not counting complementary apprenticeship training arrangements. Although a majority among the students in such systems are found in 20-odd occupational classifications for the boys and some ten classifications for the girls, attention also needs to be given to the remaining smaller classifications, especially when these are particularly environment-related as some of them are. Again, while part of the environmental education needs are similar in broad groups of occupations, each specialization may have characteristics, which necessitate some variation in the approach to the environmental education to be included in the courses.

If the systems of technical and vocational education at the entry level - that of initial technical and vocational education - are complex, even the word 'system' can be said to be inadequate for describing the situation of adult technical and vocational education for adults. Moreover, at this level differences between countries are even more marked than at the level of initial technical and vocational education. The distribution of responsibility is also generally wider; in particular the enterprises play a much more dominating role in adult technical and vocational education, courses are less formal, of shorter duration and institutional arrangements more varied. Technical universities, colleges and schools play a lesser role in most countries - in some adult technical and vocational education is even considered as outside their scope of activities.

Three types of institution should be mentioned in this context as they are likely to offer special opportunities in a search for channels through which environmental education for adult technical personnel may be diffused.

The first may be the adult training and retraining systems normally operating under the general responsibility of the labour market authorities - in some countries jointly by the labour and educational authorities. Originally designed mostly for accelerated training at semi-skilled and specialized worker levels to improve the employability of workers without skills or with obsolete skills, with the specific aim of meeting labour shortages in particular regions or industries, the systems have, in many countries gradually widened their scope to include longer term technical and vocational education and training and also extended the age range of their target populations to include also young persons only little above the compulsory school-leaving age. There is, in some countries, some considerable overlap between the activities of the system of technical and vocational education at the secondary-school age level. In other words, some of the types of environmental education, which is relevant to students in secondary level technical and vocational education is likely to be desirable also in courses provided through the adult training system.

Accelerating technological development and economic change are among the reasons why the adult training and retraining systems have been rapidly expanding in many countries in recent years. In the developing countries additional reasons have been the setting up of new industries, requiring new skills which the formal system of technical and vocational education did not have the required capacity or competence. In both industrial and developing countries often large numbers of workers have required retraining and updating of their skills and technical knowledge as processes have changed, materials used or products been modified to include new technologies. All this has served to broaden the scope of adult training systems.

New techniques, new materials, new products often means new or different environmental aspects to be taken into account, new or redesigned environmental education to be needed.

A second important channel for environmental adult education relating to technical personnel is constituted by the various extension services, which also have been rapidly expanding in recent years. Traditionally organized as 'extramural' activities of the staff of agricultural or technical colleges and universities, many extension services now constitute separate organizations. This is for instance the case of agricultural extension services in many countries and of the small industry development services, designed to improve, expand and develop artisan trade and small manufacturing business.

From an environmental point of view the agricultural extension services may be the most important agents. Their work is essentially complementary to that of the agricultural schools in countries where the latter are mainly concerned with initial training of farm workers and farmers. As young school graduates are less likely to be successful in applying environmental education lessons that they have learnt at school if the elder farmers are not similarly conditioned to take environmental issues into account in their work, close co-operation and co-ordination - in the direction of parallelism - is not only desirable but essential for achieving full effect of environmental education.

The same applies to a large extent also to small industry development efforts. Small industry and artisan services, particularly in developing countries but also in many fields of artisan manufacturing and services in the industrial ones, are a highly traditional culture; change and improvement in methods and conditions of work depends on both younger and older elements in the trade or occupation concerned.

The third major target group - or channel - in environmental education for adults - is made up by public and private enterprise. Often less structured than the two above-mentioned systems (adult employment-oriented further training and retraining and extension services for agriculture and small industry) it is increasingly important as particularly the larger enterprises in most countries are the centres of economic and technological change and often also serve as pioneers in the use of new work methods and forms of work organization, in improving working conditions and in exploring ways of reducing accident rates and reducing or eliminating occupational health risks. Inversely, due to their size and dominating place in the various fields of activity the damage they may cause to the environment and the hazards and risks to which their employees may be exposed in the inner environment of their establishments are multiples of those emerging from or applying to the middle size and smaller firms.

Educational activities of industrial and commercial enterprises have expanded rapidly in recent years. They have also become more formalized and subjected to more direct planning and management within the framework of co-ordinated personnel policies. The function of 'training and development' officer has been separated from other management functions in all larger undertakings and in many middle-size enterprises as well, making it easier to reach the enterprises with an environmental education message. Training and development or educational officers in industry and commerce in many countries have formed associations for the exchange of experience and joint discussion of educational issues within undertakings, a fact which further facilitates the contact between educational and environmental authorities on the one hand and the undertakings on the other.

Closely related to the development in undertakings are the technical education and training activities of industrial and other economic organizations such as Chambers of Industry, Federations of Agricultural Co-operatives and other bodies of which public and private enterprises are members with a view to promoting operational efficiency and economic development within their respective fields of activity. Such bodies are, on an increasing scale, participating at national levels in the design and development of educational programmes relating to their fields and are also assisting their members, in various ways, including cosultancy and direct educational action, in various aspects of personnel development. Many such bodies employ their own educational officers, some have their own conference centres and educational establishments - for instance for the training of management staff and supervisors, through which environmental education may be channelled as a complement to what is done within the formal system of technical and vocational education.

More elusive and less easy to reach are the comprehensive educational activities sponsored or run by such bodies as research institutions, consultant firms - some of which are specialized in further technical and vocational education in technical or non-technical functions. Important contact points may, in this context, be the employers' associations and Chambers of Industry and Commerce or of artisan trades and small industry where such exist - in some countries also Chambers of Agriculture. Further contacts of value in this context are the various types of management or productivity institutes and training research institutions. All the foregoing institutions and bodies normally try and keep track of the various adult technical and vocational education activities with a view to advising their bodies on the quality and usefulness of their services.

IV. PLANNING ENVIRONMENTAL EDUCATION FOR TECHNICAL AND VOCATIONAL EDUCATION

There are a set of conclusions to draw from the considerations set out in the two preceding chapters. These might be summarized as follows:

(1) There is a body of general environmental education that should be covered already in the educational process preceding technical and vocational education. At the level of technical and vocational education and training the principal aims should be - with regard to these aspects - to reinforce the environmental education already provided. If this has not been done, or not been done properly, more time and effort will have to be devoted to environmental education in courses of initial technical and vocational education in view of the key role many technical staff are likely to play in the future in the protection and improvement of the environment.

(2) At the level of technical and vocational education the principal subjects in environmental education are directly related to the occupational area in which the students are likely to be employed after graduation. It should cover both the outer environment - the relationships between the type of agricultural, industrial or other activity concerned and the world around - and the inner environment, i.e. the conditions in which the work is carried out, the major environmental risks occurring in that environment and the ways and means of protecting those involved against accidents and occupational unhealth.

(3) There is a distinction to make between the contents and form of environmental education at the various levels of technical and vocational education. Engineers, technicians (which may be at different levels) and skilled workers are differently concerned with the environment and have different possibilities for influencing it.

(4) Environmental education should be a lifelong process for technical personnel. New elements - such as new findings concerning the relationships between the use of particular materials (the asbestos case), substances or methods and specific environmental risks (with regard to either the inner or the outer environment or both) - should be diffused through both initial and further environmental education in programmes of technical and vocational education.

(5) Environmental education for students in technical and vocational education and for persons already employed in technical activities at engineer, technician or skilled-worker levels should, because of the complex nature of technical and vocational education involving both theoretical and practical instruction and the importance of the work situation and working environment in this context, be provided through a multitude of channels. These should include, in addition to the formal programmes of initial technical and vocational education within the educational and vocational training systems (full time or part time), the programmes of practical training and work experience within enterprises, the programmes for adult further train- ing and retraining, extension service activities for instance for agricultural and smaller service and manufacturing enterprises.

1. General - initial - environmental education

Students in initial technical and vocational education come with different educational backgrounds to the first year programmes. At the higher levels of technical education they have normally - exception being mainly those who have qualified through vocational or technical streams in the secondary schools in countries, where such transfer possibilities exist - completed secondary education in a science stream. It can therefore, at this level, be assumed that students in higher technical education are already familiar with such concepts as the ecosystems, energy flows in the various components of the earth ecosystem, materials flows in the biochemical cycles, population dynamics and major effects of human interventions in the natural processes. Assuming that the science teachers have covered environmental aspects largely along the lines suggested under the Unesco-UNEP programme, entrants into higher technical education would thus have acquired an awareness of the major environmental problems, have studied in broad outline their physical, economic and social causes and consequences, their geographical scale and their respective time scales. They will have acquired some basic knowledge of the social factors involved and some broad understanding of the measures that need to be taken for solving them.

In view of the great importance of environmental issues to the future graduate engineers in industry and other fields of economic activity and the time which needs to be spent on such issues during the period of study, institutions for higher technical education should test the attitudes, knowledge and understanding of them among the applicants or, at the latest, during the first year of study. To ensure appropriate teaching of environmental issues they should also communicate the results of their tests to the authorities responsible for secondary education with a view to such improvements as may prove desirable or necessary to ensure that environmental studies at the level of higher education can build on a firm foundation of knowledge of facts about ecosystems and the environmental risks existing in modern society and about the measures that have been or need to be taken at macro-economic levels - including international action - to cope with them.

Lower levels of technical and vocational education cannot, in the same way, count on initial work having been done by the schools. The students in the institutions concerned - the technical and vocational schools and colleges are generally younger, have studied less science, have probably been less exposed to environmental messages in the mass media. Moreover, particularly the students in the vocational schools are likely to retain less of what they learnt at school as they often constitute a negative intellectual selection. On the other hand skilled workers and technicians in industry and other fields of economic activity - exception made in particular for those employed in agriculture - are less likely to have a decisive influence on general environmental aspects at their respective work places. Still, what has not been done in the schools before entry into intermediate or lower technical or vocational training with regard to general environmental education must be integrated into the curricula of technical and vocational studies.

It is therefore important that also the institutions for intermediate and lower technical education test the levels of awareness of and sensitivity to environmental issues of their applicants or first-year students, their knowledge of environmental problems - in particular those relating directly to the broad field of work for which they are preparing - and their understanding of the interrelationships between the different environmental factors. Such awareness and sensitivity as they may have acquired through earlier studies

and exposure to mass media and other influences should be assessed and reinforced during the training period. This reinforcement should include the further development of skills for identifying, anticipating and solving more general environmental problems and aim at their direct participation in working towards the resolution of environmental problems in the society in which they live - an essential objective in general environmental education.

2. Occupation-oriented - initial - environmental education

There is a fundamental difference in the objectives of general environmental education and the type of environmental studies that must be covered in the curricula in technical and vocational education. In the former - in general environmental education - the primary aim is to make 'individuals and communities understand the complex nature of the natural and the built environments resulting from the interaction of their biological, physical, social, economic and cultural aspects, and acquire the knowledge, values, attitudes, and practical skills to participate in a responsible and effective way in anticipating and solving environmental problems, and the management of the quality of the environment. In technical and vocational education the primary aim is to provide the awareness, knowledge and skills required for individual and collective work in solving the acute environmental problems which exist in a particular field of economic activity or result from work in a particular occupation and to prevent new problems to arise in the outer or inner environment as a result of technological or economic change in such activities. It should further aim at improving the environmental situation at the work place as well as in the interaction between the activity concerned and the community environment. This may, in many instances mean a fundamental change in both objectives and contents compared to older laissez-aller attitudes both in the industry and in the technical and vocational education serving it.

The automobile industry may be taken as an example. It has long worked on the erroneous assumption that the emissions from an increasing number of vehicles - sulphur and carbon oxides, lead and other 'dirty' components of the exhaust gases - could easily be absorbed in the natural environment. Training of motor engineers, manufacturing and maintenance technicians and garage mechanics has generally ignored the environmental damage caused by such emissions. External pressures have, however, in recent years totally changed the emphasis in this particular field: the first was the oil price shock in the early 1970s, the second the realization - at about the same time - that irreparable damage on forests and fields - and to human beings in agglomerated areas (e.g. the smog problem) - was being caused by the exhausts. The result has been that engineers and technicians have placed much more emphasis than in the past on developing fuel-saving engines, catalysators and other technologies designed to reduce environmentally harmful gas emissions. Similar developments have taken place in airplane engine design and production with new priority being given to cleaner exhausts, less noise and better fuel economy.

External pressures have had a similar impact in a wide range of other industries and have already made their marks on both process design and production methods. A sometimes wild-grown legislation has been enacted providing maximum emission limits and targets for the 'smokestack' industries, such as iron and steel mills, pulp and paper factories, slaughterhouses, textile mills and other notoriously 'dirtying' branches of industry. Sharper controls have been introduced for emissions from domestic and industrial fuel-burning heat-producing installations, and for industries using large quantities of

water in their processes, to avoid contamination of rivers and lakes or the groundwater. Particularly sharp controls have - after a series of grave accidents - been adopted for the chemical industries handling poisonous elements; those concerned in the authorities concerned or in the industries themselves will hardly forget the much publicized and erratic wanderings of the dioxine-polluted earth, emanating from the Seveso accident in Italy - now finally neutralized through burning in the incinerators of the Basel chemical industry.

One of the principal tasks of technical and vocational education is to carry out a similar change in emphasis in the curricula and programmes of technical and vocational education - to find a place in the lesson plans for theoretical studies as well as practical instruction and work for the environmental aspects of the various courses of study and training. In this the educational institutions should, as far as possible, take an initiating role rather than, as is now often the case, follow behind developments in the industry concerned.

While the technology to be covered will differ depending upon the level of studies and the field of activity concerned a few basic objectives may be set out for such a change in the aims of technical and vocational education:

(1) to create awareness of and provide the required technological/economic knowledge and skills for dealing with the environmental problems relating to the principal products of the field of activity concerned; the possible elimination of such problems and the principal technical solutions to them;

(2) to create an awareness of and provide the required technological/economic knowledge and skills for identifying and dealing with the environmental problems arising out of the production processes which are current in the field of activity concerned, including:

   (a) recycling or direct use of process by-products;

   (b) waste disposal techniques, including separation technology applying to polluting elements in air, water and solid materials, storage and destruction of polluting and toxic agents and elements or, as the case may be, their transformation into non-toxic waste;

   (c) as appropriate, restoration techniques when the production process involves direct damage to landscape or other elements in the environment; this should include familiarization with standards applying to the industry concerned contained in legislation or recommendations by the competent authorities or other bodies;

(3) to create an awareness of and provide the required technological knowledge and skills - including safety-minded attitudes - for identifying and dealing with problems relating to safety and health of those involved in the work process, including possibilities for eliminating such environmental risks, or, as the case may be, protecting the individual or group concerned, also including the maintenance of such measures and the supervision of safe working methods.

Two comments should be added. Emphasis has - along the lines of tradition in industrial safety and health activities - been placed on eliminating the hazard or risk concerned. This should be the primary objective; not just to reach the maximum emission standards, or those designed by legislation or otherwise as 'recommended'. Whenever elimination of a risk is possible this should also be the objective. In safety work the next best is to 'build in' the risk - to put it out of reach of the workers. The same applies, mutatis mutandis, to environmental risks - e.g. safe storage. Only when this has proved impossible are such measures as equipping the workers with protective clothing or other protective gear considered desirable. It is in this general spirit and with this general objective that environmental education should be provided in technical and vocational education.

Total elimination of many environmental risks may - at least at the present state of technology - seem impossible; the automobile may again be used as an example. After the traditional 'gas-guzzlers' have come the fuel-saving engines: the road is now technically paved for a transition from leaded to non-lead petrol; the next step will be - in the late 1980s in some countries already - to reduce drastically the emission of carbon oxide and other polluting elements by catalysators and other means of reducing toxic emissions. Fifteen years ago there was little awareness of the problem as such - there was even resistance, still remaining in some quarters - in a few years time both total consumption of fuel and the quantity of toxic emissions per unit of mileage will have been reduced to a fraction of what they were then. This has been achieved despite protests that the industry would not be able to develop the technologies required within the time-limits once set, that it would be economically disastrous for car owners and transport companies and that, after all, there were many other polluting agents who were more guilty than the vehicles on the road.

The second comment relates to the economic aspects of environmental control. Generally, economic studies in technical and vocational education relate primarily to the micro-economic (business economics) aspects of production processes and products. This is by far too narrow a frame of reference in the study of environmental problems. They must be seen in a micro-economic perspective and also take account of a number of non-economic aspects. They must take account not only of the direct damage to the environment that a particular production process may cause in the immediate vicinity of the plant but also the cumulative effects in the biological systems, the international nature of many environmental problems and the impact on the structure of the industry that protective measures may have.

To the individual factory or production line, cleaning up exhausts and waste disposal may cost a few million dollars - a large sum of money in the microscopic lens of a company with a turnover of a few hundred million. In the macro-economic perspective it may be a pittance compared to the damage caused on the forests nearby and far away - ultimately perhaps resulting in soil erosion, landslides and avalanches, climatic change and other environmental damage. But competition between producers may be such that cleaning up becomes economically feasible only when an agreement has been reached between a group of factories - as has been the case, for instance, in the pulp and paper industries along the shores of the Baltic Sea. The major environmental problems of our time are often international in character and they are macro- and socio-economic in their effects on human life and, in addition, involve damage, which cannot be expressed in economic terms - such as illness or death, destruction of wildlife and endangering the very basis for agricultural production. Similarly incalculable in economic terms is the aesthetic damage

caused for instance by rivers dried up to produce electricity or the wounds left in nature when the ore has been exhausted in open-pit mining.

The same combination of macro-economic and non-economic factors must be taken into account in determining measures for improving work-place conditions and protecting workers against accident hazards and risks for occupational unhealth.

These are elements which should be included in environmental education in technical and vocational education to make students aware of the responsibilities carried by technical personnel in their work.

3. Adult - further - environmental education

There are a number of reasons why discussion and planning of environmental education in technical and vocational education should cover both the initial phase and adult, further education, involving upgrading, updating and, in some cases retraining. A few of them should be mentioned in this context as they have a bearing both on the selection of target populations and the contents of such education.

First, fast-moving technology makes continuing - lifelong and specifically targeted - technical and vocational education particularly important in the various fields of science and technology. While civic groups may receive sufficient continuing education through mass media and the activities of various social and political pressure groups and community organs, technical staff must have continuing technical and vocational education relating to the specific impact of change in their particular field of work. It may be noted in this context that many agricultural and industrial undertakings are today employing means of production that did not exist only a few decades ago, and which involve environmental risks, which are different from those they learnt to master when they received their initial training. Moreover recent research on, for instance, occupational health and more wide-ranging environmental problems has contributed to new views on what must be done or avoided - a recent example, completely upsetting a whole industry, is the set of occupational health risks connected with the use of asbestos. Many similar examples can be given from other industries.

Secondly, there must be a certain correlation between what older generations of technical personnel know and what those in initial technical and vocational education are learning. If this is not achieved current conflicts between older and younger generations at the work place will be further aggravated.

Thirdly, older generations of technical personnel have acquired their competence in courses, in which environmental aspects were largely neglected. What they need is not merely an updating, but in many cases what in fact amounts to a retraining aiming at changes in attitudes as well as in the emphasis to be given to different aspects in their work.

The prime target groups in further environmental education for adults are, in the first instance, those who are responsible for products and processes and for the maintenance of appropriate procedures at work: the managers at the various levels, including supervisors in production; specialists in research and development; maintenance personnel - including those responsible for repair and maintenance after sale, e.g. garage workers, engine tuning, repair and maintenance of petrol supply systems and catalysators are examples of recent technological change requiring further training of those concerned and which has important environmental consequences.

Self-evident targets - and channels - for further environmental education are the training and personnel development officers and the safety engineers and safety representatives of workers' unions.

In industries with dangerous substances used in production the target groups are normally even wider; they include for instance tank storage personnel, transport workers and others, who may handle such substances in their work and who, if their job is not done properly, may cause irreparable environmental damage.

More specialized groups still are the various groups of inspectors and technical service personnel; environmental protection efforts have, for instance, given new functions and responsibilities to chimney-sweeps.

Contents in further environmental education for technical personnel differ widely between the various branches of economic activity. So does the extent of the education required by those employed in the various fields. The objectives are the same as those given for initial environmental education in technical and vocational education: to develop awareness of and knowledge and skill in handling the various environmental problems which occur in the particular field of economic activity concerned as regards the products, the production process and the work process.

It must, however, in many cases be broader than the environmental education provided for adults. Technical and vocational education has, in the past, generally paid scant attention to environmental issues, except those relating to the safety precautions to be taken by workers on the job. Even this aspect is sometimes neglected, particularly in the predominantly theoretical studies in higher technical education in many countries. As a consequence, environmental education for adults may often need to have the dual objective of sensitizing the trainees and making them aware of the general environmental issues, and with the specific problems relating to the industry or other type of economic activity in which they are engaged.

The fact that many of those who do technical work in industry and other fields of economic activity already are familiar with safety work and with the health risks, which may occur in the inner environments within their particular field of work is, on the other hand, an advantage. Environmental education for such personnel can, in many respects, be designed as an enlargement and extension of what they already know about the risks which they encounter in daily life. They are also sensitized to the interrelationships between different work places and the precautions that workers must take not only to protect themselves but also to avoid damage to other people.

The degree of awareness of safety measures and health risks at work vary greatly between countries and between industries. It may be said as a generalization - with, fortunately, many positive exceptions - that smaller enterprises pay less attention to the safety and health of their employees than the larger ones. The latter, in both developing and industrial countries normally have a specialized organization for protecting their workers, often specialized safety engineers, backed up by joint safety committees and safety representatives of the union. These normally undertake both preventive and educational work within the organizations. They are also in closer contact with both the labour inspectorates and with other firms, and with specialists in occupational health. The larger firms often also employ medical staff with preventive occupational medicine as one of their special tasks.

In the smaller enterprises, on the other hand, and particularly in the workshops in the non-formal sector in developing countries, conditions are as a rule less favourable. Protective devices are often lacking on the machines; workers, often also the owner/manager, are ignorant of the health risks connected with the use of various toxic substances; there is normally little contact with the labour inspectorate, and no contact at all with medical personnel, who could help directing attention to the problems which might develop. Neglect, often due to ignorance of the environmental effects, of elementary environmental protective measures, such as proper waste disposal is common: waste oil is allowed to run out into sewers, toxic solvents are held in open vessels often combining fire risks with those of intoxication of the workers concerned. In other words, such enterprises are often a risk factor to both the outer and the inner environment.

As already mentioned the situation is further complicated by the fact that there are no established educational channels for reaching those responsible in the smaller enterprises in many countries. Apprentices do not receive related instruction in any educational system; there are no courses for master craftsmen and entrepreneurs on environmental issues as the objectives of small industry consultancy agencies are mainly commercial and technical. In industrial countries the enterprises are normally members of trade associations, chambers of small industry or other similar organizations; in the developing countries they are not ranged into any kind of formal structure through which they can be reached.

The situation is, in most countries, less unfavourable in agriculture. Farmers co-operatives, government extension services and the sales organizations of manufacturers of machinery and tools and of chemicals used in agriculture constitute channels through which environmental education can be brought out to even rather remote villages in most countries.

4. Subjects in environmental education

Planning environmental education for future and existing technical personnel is thus a complex task. Complex because of the many levels at which such education must aim; complex, because of the great variety of technical functions of such personnel; complex because of the many channels that must be used for reaching the different groups concerned - and the lack, in many cases, of adequate channels for reaching them. But important, because of the key role that technical personnel plays both in the prevention of environmental degradation and in repairing such damage as may already have been made.

Initial technical and vocational education

Planning environmental education in fully institutionalized - particularly full time - technical and vocational education is a relatively straightforward task. Here the principal choices in planning relate to the extent to which environmental education should form a subject of its own and the extent to which it may be incorporated into the various technical subjects, or, as the case may be, the teaching of general science. A further set of choices relate to the place and form of environmental education in theoretical and practical instruction respectively, and through special studies or training on-the-job.

In higher technical education, whatever the specialization, a general course on environmental issues with particular reference to polluting wastes and emissions and with an emphasis on the technology used in filtering, desulphurizing, neutralizing and destructive and storage operations should be the first objective in planning. The course should aim at conveying a sense of responsibility of technical staff at all levels for the maintenance and improvement of the outer environment and provide theoretical/technical knowledge of both the polluting effects on the environment of careless waste disposal and the means existing for preventing them. It should be complemented by practical applications in the laboratory and the workshop. While examples used in both theoretical and practical instruction should relate directly to situations in the occupational area concerned, the basic message should be the same: environmental damage can and must be stopped - stopping it is largely a matter of appropriate technologies being used by responsible technical staff.

The course should also cover main aspects relating to the inner environment. It should convey knowledge of basic ergonomic and industrial engineering and safety principles and practices, elements of industrial hygiene and basic knowledge of both common health risks and preventive measures. As in the case of environmental education relating to the world outside, the course should include practical experiments in laboratory and workshops in the application of the theory learnt in the lecture rooms. Special emphasis should be given to the various respiratory, allergic and other affections which develop slowly, including the effects of cancerogeneous substances, affections relating to eyes and hearing (noise levels), and to the precautions that must be taken to prevent them to develop.

An important additional objective in a special environmental course for students in higher education should be to familiarize the students with the activities and norms of the various public authorities and private bodies concerned with general environmental issues, industrial safety and health, fire prevention - with special reference to industrial fire risks, use and storage of inflammable and explosive materials, self-ignition processes, etc. - waste disposal, and economic use of energy and of raw materials in limited supply, including recoverage and recycling.

While emphasis should be on environmental issues and on the technology of environmental protection - and include reinforcement of the general environmental education provided in secondary education - the course should also stress both the socio-economic and the micro-economic aspects of environmental protection and the economic use of raw materials in limited supply.

Environmental protection and improvement offers a wide range of excellent subjects for graduation projects: teams of students or individuals can benefit greatly from carrying out special studies of environmental protection problems in particular industries or plants; there are many, yet unsolved or only partly solved problems of waste disposal, air- and water-born toxic and polluting emissions, which constitute potentially fruitful challenges for postgraduate thesis work. Fruitful because a technological advance in these areas can be both financially rewarding and an introduction to a successful technical career.

At the level of intermediate technical education the objectives in environmental education should be about the same as those suggested above for the future graduate engineers. Any difference in approach might relate to emphasis rather than substance. Technicians, as a rule, will be more directly

concerned with the application of known technologies for environmental protection and improvement than with the development of new or improved technologies. Moreover, the tuition provided should emphasize the practical applications rather than the theory, which implies that lecture-room time should yield somewhat to workshop and laboratory activities. Familiarization with norms for maximum emissions should be more directly concerned with how to reduce current emissions than with questions on how the polluting elements are constituted and what theoretical and practical problems must be solved to eliminate or reduce them.

Finally, environmental education at the intermediate levels of technical education will need to be more specialized - cover a narrower share of technological applications - than that required in higher technical education. As pointed out in a previous chapter technician training normally relates to a narrower field of technical work - courses are, as a rule, shorter than in the technical universities and other institutions of higher technical education, which also means it is more difficult to make room in the curricula for the type of comprehensive course on environmental issues outlined above.

In designing environmental education for technician-level courses attention should also be given to the type of work normally done by the graduates in the early years of employment. This varies greatly between countries and between industries. In the chemical industry, for instance, technicians are often put in charge of smaller production units, while in the mechanical industry the early years in employment are often spent on specialized work in planning, work study and other similar tasks, or as assistants to operating managers. Specialized chemical technicians often spend some years in the research and production control laboratories. Technicians in industries applying established and traditional technologies - as is often the case in developing countries - will gain a different type of experience compared to those, who spend their first years in a dynamic, technological front-line atmosphere. The type of experience they will gain and the relevance it will have to environmental issues will vary along with these parameters.

A distinction must also be made between technician training which is parallel to senior secondary education, on the one hand, and post-secondary technician training, on the other. The former normally have less environmental education before entry as they have left general education about the age of 16; the latter have mostly graduated from science streams or their equivalents in secondary education and are likely to have a reasonable grasp of the general environmental issues.

The upshot is that environmental education in intermediate technical education will have to be designed taking a number of variables into account. For the lower age levels - those going into technician training already around age 16 - a general and basic environmental education course may be necessary to provide a frame of reference for the more detailed study of industrial environmental issues or, as the case may be, environmental issues relating to work in agriculture, forestry, mining or other fields of economic activity outside industry proper. The more specific industry-related environmental education will, in most cases, have to be comparatively narrowly focused on environmental problems directly related to the specialization of the students. Thus, for instance, chemical students may be guided primarily towards the study of preventive measures concerning toxic, corrosive, cancerogeneous and more generally substances, which, if allowed to flow freely into the environment may cause damage to aquatic life or to, for instance sewer installations

or through air pollution; they should, as a corollary to risk studies also be familiarized with the precautions to be taken to avoid environmental pollution or other damage, the properties and construction of common environmental protection measures and technologies and the emission standards applying to their particular branch of chemical work. They should also be introduced to and learn to work with the major sources of information about and control of environmental norms, as well as the relevant standards applying to industrial safety and health. Important elements for chemical technicians are also such aspects as fire protection, including self-ignition risks, special safety measures relating to pressurized containers and the technology pertaining to them.

Technician trainees preparing for work in other industries have different needs in environmental education. Noise problems, for instance, occur in a wide range of activities - textiles, aircraft service, civil engineering can be given as examples of industries where protection against high noise levels constitutes an acute problem. Vibration is the cause of occupational health problems in forestry work (motor saws) and civil engineering but are also more general environmental problems; polluting emissions are common (although the substances may differ) in a wide range of industries such as pulp and paper, in the chemical treatment of parts in the mechanical industry, in the finishing departments of textile factories, just to name a few examples. Rubber and plastics factories combine emission problems with such relating to safety and health due to the use of various types of solvants and a wide range of industries, including those already mentioned, risk polluting the environment through residues flowing through their water outlets (for instance fibres from textile factories) or influence the climatic conditions in rivers by letting out heated water. Common to all traditional 'smoke-stack' industries are the problems created by chimney smoke, often combined with other emissions into air and water and in all cases a source of serious pollution unless proper steps have been taken to clean up. Broad groups of students in intermediate technical education therefore need to understand the effects on aquatic life and the environment more generally of the more common industrial emissions, the means of controlling them and the maintenance of acceptable standards in this respect.

Widely applicable, and for this reason also an important element in environmental education for technicians preparing for work in broad groups of economic activity are various energy saving techniques, such as heat exchanging - for the dual purpose of environmental protection and operational economy, and, more generally, heating and cooling technologies.

The examples may serve to show the degree to which environmental education at the technician levels need to be 'taylor-made' taking into account the type of functions normally given to newly graduated technicians in industry; the type of industry mostly recruiting the graduates from the various streams of intermediate technical education; the environmental risks - relating to the outer environment as well as to the safety and health of workers and others employed in it; and the type and level of general education they have gone through before entry into technical education.

Environmental education for trainees in <u>lower technical and vocational education</u> offers the same problems as those applying to intermediate level technical education. Time is often short: full-time training to skilled worker levels in vocational schools often lasts for only two years. Specialization is

often narrowly defined as to the type of industry, or function for which training is provided. The educational level attained before entry into lower technical and vocational education is often low - eight or nine years of general education is about the rule. Moreover, as already mentioned, the recruits into this form of technical and vocational education often constitute an intellectually negative selection, with a large proportion of 'school-tired' pupils with little interest in and aptitude for further 'bookish' studies.

Their general environmental education is likely to be somewhat deficient - a want that needs to be met in their educational programme. Such supplementary environmental education is desirable not only in the same way as it is desirable for secondary-school students in general but also as a frame of reference for the more directly occupation-related environmental education which should form part of their theoretical and practical instruction.

As the occupational areas are even more diverse at lower technical and vocational training than in other forms of technical education no generalization can be made about the contents. Obviously mechanics and electricians need quite different environmental education - and will be able to influence the environment more effectively in their future work - than for instance hairdressers or shoemakers.

As a general rule it might be suggested that persons preparing for skilled work in agriculture and related fields of economic activity need the most wide-ranging and intensive environmental education. The risks which are relevant in their work relate both to the outer and the inner environment, and to occupational safety and health. The widening use of artificial fertilizers as well as natural manure and other chemicals, all with polluting potentials and many also implying occupational health risks if not handled properly are basic examples of environmental issues, which they need to study thoroughly and also learn to handle the relevant protective technologies. The concentration of livestock and other food production into 'meat factories' has given rise to new and often technologically complex waste disposal problems, which they must learn to handle. They must develop insight and understanding for the chain effects in nature of indiscriminate use of weed-killers and insecticides and the use of other chemicals for instance pickling of seeds, etc. In other words they need both a thorough grounding in the agricultural ecosystem and in the technologies used for protecting it, and a rather comprehensive introduction to safety and occupational health problems in an increasingly accident-prone occupational field.

For factory occupations the specialized environmental education required is normally narrower and more directly related to the safety and health of the work team and the risks directly related to the type of production. Chemical workers often need more comprehensive and basic environmental education relating to the handling of the products - unless the production is entirely automated - which often carry risks involving gas leaks, poisoning, inhalation of dust and other health hazards. They must be familiar with safety arrangements, including precautions relating to gas stored under pressure, and of emergency routines - knowledge and skills, which, incidentally, are in most cases best learnt in practice on the job. The environmental education off-the-job should in the first instance aim at awareness and understanding for the problems, while the skills should as a rule be acquired in real work situations.

Common to most skilled worker classifications is that their education should include study of the general safety and health organization at the work place, basic ergonomic principles applying to the various work functions - sitting, standing, lifting, balance in movements, etc. - the respect needed for orderliness at the work place - individually as well as the collective inner environment - and the strict application of safety rules and regulations.

Special emphasis on environmental issues is required in such occupations which relate to repair and maintenance of installations and equipment - mechanics, electricians for instance, including automotive vehicle mechanics, who, in their work, are likely to control and maintain equipment which has a bearing on potentially polluting emissions.

Summing up, environmental education in lower technical and vocational education must be highly selective, in the first instance complementary to general environmental education, and, as a further objective directed towards the environmental risks that the worker concerned is likely to deal with directly in his work. There is a risk of doing both too little and too much - general instruction about environmental risks is not likely to be effective, while omitting any aspect that the future worker can influence in the future would be an equally great mistake.

A word should finally be said about the various systems through which skilled workers are trained. In full-time vocational training related instruction normally takes up a considerable proportion of the time - together with further general education often as much as half the time is spent in the classroom. The subjects covered include general science and trade-related technology, which makes it possible to find a proper place for environmental education. The situation is often different in the 'dual systems', where related instruction is provided in group release or day release courses or in evening courses - the latter a disappearing practice. Total time devoted to related instruction and further general education varies between some 300 and 400 hours per annum. Moreover, particularly in smaller schools, pupils are often grouped in broad occupational areas, making it difficult, if not impossible to target the instruction more precisely on the technology and environmental issues pertinent to each occupational specialization. In addition, the time devoted to technology and science varies greatly between countries. In all such cases the choice of content will necessarily be to aim, in the first instance, at creating basic awareness of environmental problems both in the world at large and at the work place; to cover the essential basic principles and practices of environmental protection in somewhat general terms - perhaps with special emphasis on waste disposal, which applies to most fields of economic activity and a broad range of occupations, to provide an initiation in such fields as basic ergonomic and organizational principles and practices related to occupational safety and health and to develop favourable attitudes to the efforts made in industry and in the society as a whole to protect and improve the environment and to protect workers against accidents and health risks related to their occupations.

Further environmental education

Little can be generalized concerning the subjects that need to be included in further environmental education for technical personnel. On the whole the subject-matter can be defined under three headings:

(1) subjects, which require reinforcement - continuing safety and health education, for instance, or review training on waste disposal and related matters;

(2) complementary training, e.g. for managers, foremen and other personnel in responsibility for others, at the time of change in functions; and

(3) updating to convey knowledge of newly discovered environmental risks, or when materials used, products or production methods are changed.

Experience in safety work in industry has proved that the safety message needs frequent repetition to ensure continuing application of the rules. It also needs to be varied with shifting emphasis and using different means of communication - bad habits easily reappear after the first impressions of a safety campaign have fallen into oblivion and other priorities - piece rate earnings, production targets to be met - take over in determining behaviour. The same applies to the wider environmental issues such as maintenance of filtering equipment, the use of protective devices and so on.

Moreover, turnover among workers may be such that the environmental awareness and interest is shared only by a few members of the work force - the new ones have been rapidly trained for their jobs without sufficient attention being paid to environmental protection and improvement.

Principal targets for such further environmental education are the engineers and technicians, foremen and lead workers, who are responsible for the continuing operation of the plant or other installations concerned.

Further training connected with promotion merits special mention in this context. It is not unusual - promotion from worker to foreman is a typical example - that persons in industry are promoted from a job involving relatively little responsibility for environmental and safety and health issues to such, in which environmental problems constitute central tasks. Success in the new job will be possible only if the promotion is accompanied by proper environmental and safety training - a memento in particular for management and supervisor training courses often run by the extension services of technical and vocational colleges and schools.

V. TEACHER TRAINING

All technical and vocational education should be - and normally is - an integrated process combining three distinct elements:

(1) study of science and technology relating to the particular occupational field concerned; here the aim is to create a basic understanding for the various processes and technologies applied within that field, the scientific principles applied and the nature of the technology used;

(2) development of skills in handling the tools and equipment used within the occupational field, including, as appropriate, the tools of research and development, design and control; aim: 'know and can do';

(3) application of the theoretical knowledge and practical skills in operational situations with the objective of placing what is learnt in the classroom or amphitheatre and in simulated situations in college or school workshops into a realistic perspective and, in particular, to gain experience of the special culture of organized production and of people working together.

Like all other technical and vocational education, environmental education in such education should be provided through all three channels of learning. It is equally important that the students learn to appreciate and understand the complex interrelationships between technical activities and the environment, and get an insight into the problems encountered in this field, that they learn to handle environmental problems existing or evolving in their particular field of specialization with a view to solving them, and that they acquire direct experience of the constraints and limitations which might exist in a work place situation, the influence of human organizational and economic factors in decision-making and application of environmental protection measures and the special risks and problems which occur in work situations as distinct from the less realistic - simulating - atmosphere of a technical university, college or technical and vocational school workshop, let alone the classroom.

Learning environmental discipline is first of all a question of knowing - and having direct experience of - how an environmentally well organized work place is arranged. This is a point on which not all school or college laboratories and workshops could serve as models. It is the first aspect to be reviewed in planning environmental education in vocational and technical education. Do the machines have proper safeguards? Are tools and equipment in perfect shape, properly stored, sharpened and honed? Is workshop layout in line with the principles for good works organization - proper distances between machines, for instance? Is waste disposal properly organized? Is ventilation sufficient? Are welding booths large enough and sufficiently closed to hinder sparks to fly around (fire risks), and sufficiently ventilated to protect the trainees from intoxication? Is workshop ventilation generally properly arranged to take care of dust, shavings, gas emissions? Are wastes properly disposed of and inflammable or intoxicating substances properly stored? A few examples only of the questions which relate to environmental precautions and necessary environmental arrangements to provide

students with a proper environmental experience during their practical training in laboratories and college or school workshops.

Teacher and subject diversity

Teacher training in environmental aspects of technical and vocational education differs in many respects from what needs to be done in teacher training in general environmental education. First, there are three distinct learning situations with different personnel responsible for the teaching process: teachers of theoretical subjects in the classrooms; instructors in practical subjects in the college and school laboratories and workshops; and engineers, foremen, technicians and skilled workers in job-based training and work experience.

Already in the universities, colleges and schools providing technical and vocational education there is a great difference in the educational background and levels of the different groups in the teaching staff. While at academic levels teachers normally have high level academic degrees based on essentially theoretical studies and research work, they are seconded in the laboratories and workshops by technicians and skilled workers whose general education normally - there are great differences in this respect between countries - ended at the age of 16 with a part-time supplement of related instruction in the course of their vocational school training or apprenticeship. Formal teacher training is often not required either of the professors or of the technical staff in laboratories and workshops at the level of technical universities as the qualifications required are normally, at the higher levels, proved research proficiency and wide-ranging knowledge of the subject (mainly theoretical) and, at the lower level, highly developed skills, often supplemented by some practical experience from industry.

About the same situation exists in technician training institutions - theoretical subjects are taught by academically trained personnel, practical subjects by instructors with essentially practical training and experience. The situation has improved somewhat in some countries in recent years as technical teacher training institutions have been set up. But the general rule is still that in most countries qualification as a teacher in technical and vocational education is essentially based on academic merits for theoretical instruction and practical training and work experience for laboratory and workshop instruction in practical subjects.

The same division between two categories of teachers exists in most vocational school systems. Here teacher training is generally even less developed in many countries. Especially workshop instructors are given a few weeks of special teacher training - mainly pedagogical subjects - before they start their work; their essential qualification is that they have completed basic technical/vocational training and have some experience from practical work in industry. In many developing countries where the colleges and schools have difficulties in competing with industry in recruiting competent staff, instructors often come directly out of the vocational school, receive some additional teacher training, but are lacking practical experience from real work situations.

The personnel which carry out the essential teaching during the periods of practical experience constitute an even more mixed lot. On-the-job instruction is normally carried out by lead workers and other experienced persons under the general supervision of foremen and charge-hands. Many among them

have completed skilled-worker training - normally with a base of lower secondary general education only. Some inputs - particularly in the case of students in higher technical education gaining experience in industry - may be made by engineers and technicians, but vocational school trainees are normally left with the workers on the floor to pick up whatever they can get.

A few - particularly larger - enterprises have trained instructors on the job as well as in their off-the-job training institutions, who specialize in such work; some apprentice training systems require elementary training in pedagogy and teaching methods to be included in the training courses for journeymen to become master craftsmen; job instruction often is one of the elements in foreman training courses. However, many foremen, skilled workers and others taking care of instructing functions on the job in industry or other fields of economic activity have never received any special training for such purposes. Moreover, many among them, particularly in countries in which the organization of worker training is of relatively recent date - and they are many among both developing and industrial countries - have never had any formal training at all but have essentially developed their skills and technical knowledge through informal on-the-job training processes and supplemented them through self-studies.

Thus, briefly summarized: the technical and vocational teachers constitute a heterogeneous group of people with widely differing educational levels, widely differing types of technical and vocational training, and widely differing levels of practical experience outside the educational system in which they are employed. There are three different locations in which environmental elements are included in the instruction process: the classroom, the laboratory/workshops (training fields in agricultural education), and the full-scale work situation.

Second, there is a wide diversity in what needs to be conveyed through environmental teacher training. Each specialization requires different content and emphasis. The different levels vary in the degree of specialization: broadly defined at the higher levels of technical education; increasingly narrowly conceived at the intermediate and lower levels.

Common subjects

There is a core of general technical environmental training that applies to most if not all lines of teacher training for technical and vocational education. It relates to generally applicable ergonomic principles and practices, work place organization, common health risks in working environments, organization and sources of information concerning environmental issues, including safety and health questions, emission standards and radiation sources. Such matters can, in principle at least, be brought together into a general environmental course in most if not all technical teacher training courses in pre-service training. It can partly be amalgamated with the teaching of industrial engineering programmes and with technical programmes and, at the same time, be used to follow through on general environmental education provided in general secondary education and in initial technical and vocational education. It can be supplemented and reinforced through periodical in-service training, when new developments in the above fields should be highlighted.

But the bulk of environmental education for technical and vocational teachers and instructors must be relatively narrowly targeted on individual subject areas in the same way as environmental education in both initial and

further technical and vocational training should be selective in its design and content. Broad groups of teachers need to be familiarized with such environmentally important and broadly applicable technologies as internal materials handling, filtering of water and exhausts, and protection against ionized and non-ionized radiation, occupational disease risks due to, for instance, dust, noise, climatic conditions at the work place, etc. More narrowly focused - as regards the target populations as well as subject-matter - will be such matters as environmental protection in office operations - practically limited to the internal environment, including such occupational health problems as correct posture, radiation and eye fatigue (video screens) and climatic conditions of work. Equally narrowly focused as regards the target population but much wider in subject-matter will be the type and content of environmental education required by teachers concerned with the training of personnel for such activities as agricultural and forestry education, textiles, chemical and mechanical engineering and mining - with differences depending on the level of teaching within the systems of technical and vocational education.

The essential elements of the environmental education pertaining to each particular field of economic activity should, in principle, have been covered already in the initial technical or vocational education that the candidates to teacher training have acquired. The first task in recruitment and at the early stages of teacher training should therefore be to assess the awareness, knowledge and skills in environmental matters that the future teachers have already acquired. It should be possible in pre-service teacher training to concentrate on reinforcing what has already been learnt beforehand and on filling such gaps as may have been left in earlier educational processes. In-service training should mainly be directed towards two objectives:

(1) updating of knowledge as new developments take place; and

(2) providing essential environmental education for those teachers who have not received teacher training, and in particular those who have not benefited from any formal initial technical or vocational education.

A word should finally be said about the integration of environmental education into other subjects in teacher training. This is a difficult subject for international discussion in view of the wide variations in teacher training practices and sources of recruitment of teachers in technical and vocational education. All that can be said with reasonable international validity would seem to be that while some subjects in environmental education such as general ergonomic principles and practices, fire protection, basic issues in occupational health and protection against accidents, possibly also the effects of pollution of various kinds of water and air, as well as proper disposal of wastes from industrial and other forms of economic activity, may well be brought together into a core subject, environmental protection aspects should be taken into account in the teaching of all technical subjects in the classrooms, as well as in college and school laboratories and workshops, and in periods of practical experience. This means that all those who, in these various situations, are responsible for a part of the training process need to be given environmental training in some form.

The channels for such training will vary depending on the particular national practices and institutional arrangements. First in line are, of course, the teacher training institutions, which provide initial teacher

training. Second in line are those institutions - if not the same - that cater for in-service training of full-time teaching staff. Third, the various extension services, management training institutions (including supervisor training institutions) and industrial training and development associations that might exist. Fourth, and not the least important the mass media and, in particular, the professional journals which are commonly reaching the teachers and instructors in technical and vocational education and the engineers and supervisors, who are responsible for on-the-job training and experience.

VI. SUMMARY AND CONCLUSIONS

The growing importance of environmental issues in modern society and increasing risks for irreversible damage to the outer environment as well as for accidents and occupational disease, in the work environment combine to emphasize a need for review and further development of environmental education in technical and vocational education.

The subject is difficult for three main reasons. First, the wide variety of environmental risks, which have their origin in the various fields of economic activity. There are the direct risks of environmental pollution through waste emissions carried by water or let out into the air; there is improper disposal of solid wastes; there is unsafe storage of inflammables and toxic substances. There are also the chain effects in nature of improper spreading of fertilizers, insecticides, pesticides and weed-killers, lead, mercury and other heavy metals, of sulphuroxides and carbon monoxide, fluor salts and other chemical substances which, in high doses, have toxic effects on animals and human beings, or may be lethal to plants and trees. There are the many risks which pertain to the inner - working environment; the use of new methods of production, newly developed materials or older raw materials, which have proved the cause of occupational unhealth; improper organization of work or work place arrangements, which favour accidents or ill health among the workers.

Second, there is the wide diversity in technical and vocational education. There are three levels - at least - at which technical personnel to be employed in agriculture, forestry, industry, commerce and other fields of economic and social activity are trained: at university level for engineers and other technical staff at similar levels; in technical colleges and technical secondary schools in which technicians - itself not a homogeneous level in all countries - receive their initial technical education. There are various types of lower technical and vocational schools - part-time and full-time - in which skilled workers develop their basic trade skill and knowledge. While most engineers and technicians today receive their initial training in full-time courses, an important complement is provided in industry and other fields of economic activity through periods of practice and technical initiation as well as graduation and graduate research and development projects. Skilled and specialized workers, finally, pick up their initial skills and knowledge of technical work either in the vocational school programmes or through a combination of part-time vocational education and practical training on-the-job, or through informal training in employment without any complementary education at all.

Third, it is a fast-moving subject. Research provides new evidence practically daily of health risks in the use of various substances - risks for cancer, respiratory diseases, eczema and various allergic affections. In other words, it is a subject in which a dose of initial training will never be enough. A strategy of environmental education for future and present technical personnel must include provisions for both initial and further training on environmental issues - at the level of initial technical and vocational education and at the level of adult further education for those already active in one or the other of the many fields of economic activity. These fields differ widely with regard to the types of risk that they involve as far as both the

outer and inner environments are concerned. Some are heavy polluters, others may be less menacing to the outer environment; some are particularly dangerous to those working in them. In all fields there are environmental issues to be taken into account, elements of potential damage to the world around or to those engaged in the work.

Technical staff at all levels have a heavy responsibility for the protection of the environment and for improving it whenever this is possible. They are directly engaged in the development of new products and materials, for the design of work processes, for the development, operation and control of technical installations, for ensuring that process outputs and by-products are properly designed in line with set standards and that these standards are properly maintained, and that wastes are properly taken care of.

The range of their responsibilities for environmental protection and improvement varies between the different levels of work. Engineers and managers of technical operations have to assume responsibility for a wider range of environmental issues than the individual worker. But each in his work can often both be the cause of environmental damage and be the initiator of environmental improvement.

There is no direct link between the technical and vocational education that a person has received and the field of economic activity or type of functions which he may have in working life. Mechanical and electrical engineers and technicians are working in enterprises and other bodies ranging from social services such as hospitals to line construction and maintenance or factory work, mechanics may end up as maintenance men in office establishments and so on.

All this diversity means that environmental education must be specifically target to well defined populations and well defined fields of activity with clear definition of priority issues in environmental protection and improvement.

The objective in all environmental education - as defined by the Unesco/UNEP Tbilisi Intergovernmental Conference on Environmental Education (1977) is to make individuals and communities understand the complex nature of the natural and the built environments resulting from the interaction of their biological, physical, social, economic and cultural aspects, and acquire the knowledge, values, attitudes, and practical skills to participate in a responsible and effective way in anticipating and solving environmental problems, and in the management of the quality of the environment. Moreover, environmental education should show clearly the economic, political and ecological interdependence of the modern world - the small world of the work place, the larger world of the locality, the region and the nation, and the wider world of international interdependence.

Specifically environmental education in technical and vocational education - taking off from and reinforcing whatever basis general environmental education might have provided - should aim at making students and trainees aware of the specific environmental problems and risks, including those relating to the safety and health of the working group, that relate to the type of industry and occupation which the students are preparing to enter and which are involved in the type of functions that they are learning to carry in economic life. They should, in addition, learn the theoretical and scientific basis - adapted to the level of studies - of the technology applied

to cope with the problems and the skills required for applying it. The training should relate, as appropriate at each level, to the construction and design, use and maintenance of protective measures and to the technology that might be applied in reducing or removing the risks to the environment that applies to the relevant area of technical activity.

Environmental education in technical and vocational education may, with regard to the essential basis for environmental protection and improvement and the protection of those working against accidents and unhealth, be treated as a separate subject, designed to supplement and reinforce what has been learnt previously in general environmental education, and to widen the awareness, knowledge and skills acquired in it to relate more exactly to the particular risks and possibilities of the occupational area concerned. In its essentials environmental education should, however, be integrated into the total technical learning process. Many aspects of environmental education will fit well into the teaching of such subjects as industrial engineering and the organization of work; industrial law; mechanical and electrical engineering; building and construction technology; and agricultural technology and botanics.

Environmental education should be a cross-cutting theme in all aspects of technical and vocational education. It should be emphasized and explained in the study of theoretical subjects, constitute a leading theme in laboratory and workshop skill training, constitute subject-matter for thesis work at undergraduate and graduate levels and form an important part of the practical training and experience gained on-the-job.

Environmental aspects - with, perhaps, the exception of industrial safety and health - has often been a neglected aspect of technical and vocational education in the past. It has not been given any prominent place in teacher training for such education. It is of greatest importance for future generations of technical staff that such lacunae should now be filled. This means, first of all, that teacher training curricula should be reviewed and, so far as required to repair past omissions, revised to give environmental education its proper place in them. It also means that programmes of further - in-service - training of existing training and teaching staff may need to be developed to ensure rapid adaptation of the current teaching process to new or previously neglected environmental education requirements.